Current Thinking on Measurements to be Performed at the First Probe Entry into Lake Vostok .

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The very first entry of a probe into Lake Vostok will require that extraordinary precautions be exercised to assure that the vehicle and the instrumentation be clean of biological material. A number of researchers are currently examining this issue, seeking an approach that will meet both scientific and programmatic requirements. At the present time limited knowledge is available on an accepted approach, but the best examples for consideration exist with the medical/hospital protocols and those practiced by the communicable disease research community. However, many advanced, state-or-the-art micro-instruments may not survive the cleaning and sterilization processes deemed required for adequate protection during the first entries into Vostok.

The classes of measurements to be performed generally partition into two major catagories: Physical/Chemical and Biological/Environmental. Different types of instrumentation are used for each class and their survivability and usage viability to the eventually selected Planetary Protection approaches remain to be certified. However, each class defines what might be measured to provide critical information about the Lake, the ice just above it and its sediment bed. By the very nature of the difficulties expected in certifying the cleanliness of the probe, the first entry will require robust instrumentation and may be limited to a small subset of the most desirable measurements. The present assessment tries to balance the exploration requirements against the quite limited payload volume, cleaning/sterilization requirements, and modest funding availability.

Physical/Chemical Meaurements:

Among the least difficult measurements to perform are those that help to define the present state of the Lake and the melt water just produced by a melting warm-tip probe. These measurements provide a basis for understanding the presence of any detected organic material or existing, viable life forms.
Vertical Profiles or Spot Measurements of Physical Conditions:
1) Local, spot temperatures as well as measurements of a thermal profile within both the water and the sediment bed are important physical parameters. If the initial entry point were selected to be near a 'shoreline' where the Lake water was about 20 m or so in depth, this might be possible. At present, the freezing point of freshwater ice subjected to 3.8 km of overpressure is estimated to be around -5 Celsius, and this is probably the temperature of the Lake water at the water-ice interface. Is the water thermally stratified, indicating little convective circulation? Are there any thermal anomalies that would provide large scale circulation and gradients for nutrient redistribution? Devices such as micro-platinum resistance thermometers, thermocouples and thermistors are generally robust and should be capable of being fabricated to work in the suspected environments after rigorous cleaning.
2) Salinity and pH both provide important clues as to the current state of the Lake and recent evolutionary pathways. Significant deviations from a freshwater composition provide information regarding potential entry of sea water and chemical imbalances. Sensors exist within the medical community that have undergone stringent bio-cleaning

and should be available as-is, or with modest modifications to function in the Lake Vostok water environment.

3) Turbidity and floating Particulates provide information on nucleation processes and circulation within the Lake water. In some cases, if visible wavelength illumination is used, particle size information can be extracted, but that depending on the specific nature of the detectors employed. Modern light-emitting diodes (LEDs) coupled to fiber optic bundles enable color coverage from 450 to 1100 nm when matched to silicon array detectors.

4) Visible Presence is an important attribute for human endeavors where few, if any, humans might venture. Given the potential expense of the venture, it is important to be able to provide images to the public in a timely manner to maintain their interest and support. In time, it is conceivable that Lake Vostok would be explored via remote research submersibles with large complements imaging systems, and later human-piloted explorations could provide a true presence. However, as long as the Lake is to be maintained as pristine as possible, such larger, more capable craft are unlikely. To provide some alternative, advanced micro-scale imaging systems can be incorporated into sealed compartments within the probe, using fiber optic bundles to interface with exterior wall sapphire windows designed to withstand pressure differentials and thorough bio-cleaning. Illumination for such sensors would be provided by the LEDs described above and the imaging system could also act as the scattering signal detector for the turbidity and particulate investigation. If the probe remains tethered via a data line to the Antarctic surface, high speed video rate transmission of imagery is possible. In-ice repeater stations might also be used, with some transmission bandwidth loss.

Biological/Environmental Measurements:

There are many instruments and measurement methods possible to pursue the question of whether Lake Vostok has present-day biological activity or had it in the recent past. Unfortunately, the definitive instrumentation, such as Scanning Electron and Ion Probe Microscopes, Capillary Electrophoresis and Culture-growing approaches are either vastly too large or difficult to bio-clean. For the very first entry, a few other approaches appear to lend themselves to possibly being viable for use a few years from now.

1) Redox Sensors for non-chemical equilibrium concentrations of reduced iron and manganese, along with the oxides of nitrogen and sulfur, provide a strong indication of life processes on this planet. Measurement of the dissolved molecular oxygen content of the water also assists in this determination. Recent developments in the electrochemistry field have produced miniature sensors capable of being fabricated to withstand high pressure liquid environments and perform square-wave voltammetric analyses of the liquid environment for the species of interest. We envision that an array of these sensors would be included in the first probe to provide a quantitative examination of the Lake water and examine whether dis-equilibrium conditions potentially caused by life processes might exist.

2) UV Raman & Fluorescence Spectrometry are analytical methods that provide inordinate sensitivity to large biological molecules and bacteria. Recent work has shown that under proper conditions, it is possible to detect as few as 5 to 10 bacteria on a surface and acquire some classification information at the same time. As this analytical approach improves during the next few years, it seems likely at an instrument of small size (about 1 -2 liters volume, 2 kg mass and 4 or 5 watts power consumption) can be developed to fit within the instrument compartment of a melt probe. Miniature UV lasers and flash lamps exist and as their operational wavelengths reach 220-250 nm, detection

of fragments of RNA and DNA becomes possible. Such an instrument would provide critically valuable capabilities, not only for the assay of the Lake water, but for control checks of the bio-cleaning processes on the probe.

* The work described was performed at the Jet Propulsion Laboratory, California Institute of Technology under contract with the National Aeronautics and Space Administration.